Advanced Control Systems (Examples)

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(in collaboration with colleagues & students)

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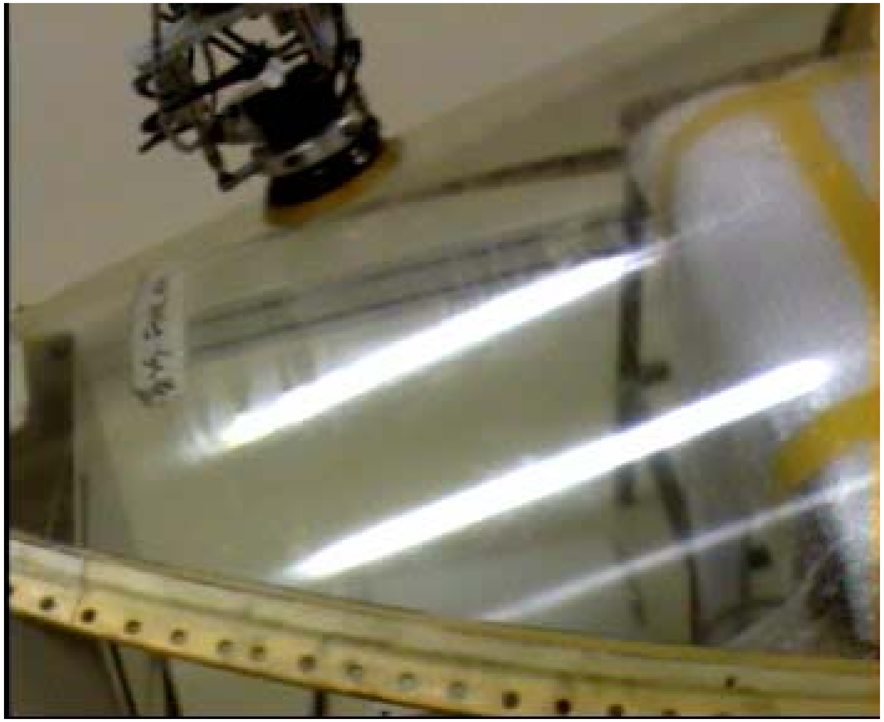
aircraft canopy polishing



Advanced Control Systems projects: prototypes being refined in different stages

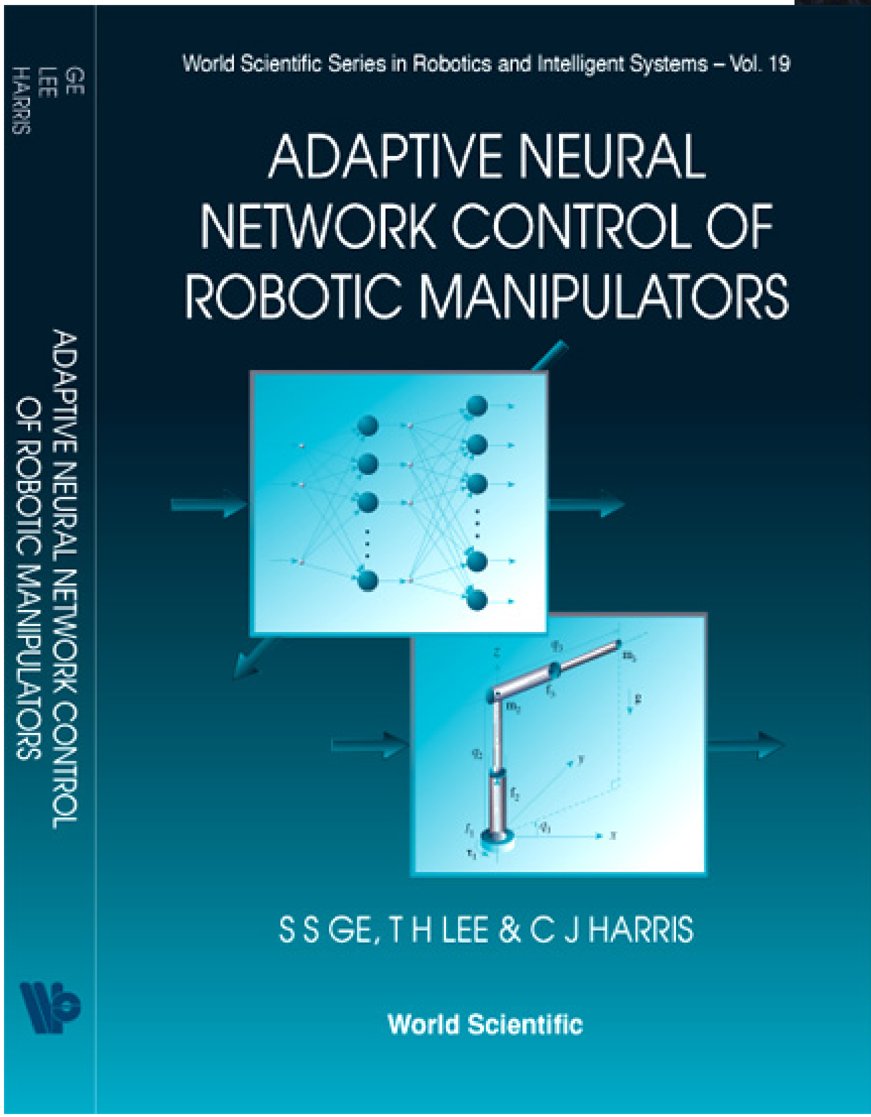
Fukuda & co-workers (Nagoya)
Lewis & co-workers (Arlington)
Moore & co-workers (Utah)
Grimble & co-workers (Strathclyde)
Tso & co-workers (Hong Kong)
C.W. de Silva & co-workers (UBC)

Other Systems (at CIC, NUS)

Gladiator Robots

Pole-balancing Robot

Some of the other fun things our students work on…


World Scientific Series in Robotics and Intelligent Systems – Vol. 19
ADAPTIVE NEURAL NETWORK CONTROL OF ROBOTIC MANIPULATORS
S S GE, T H LEE & C J HARRIS
World Scientific
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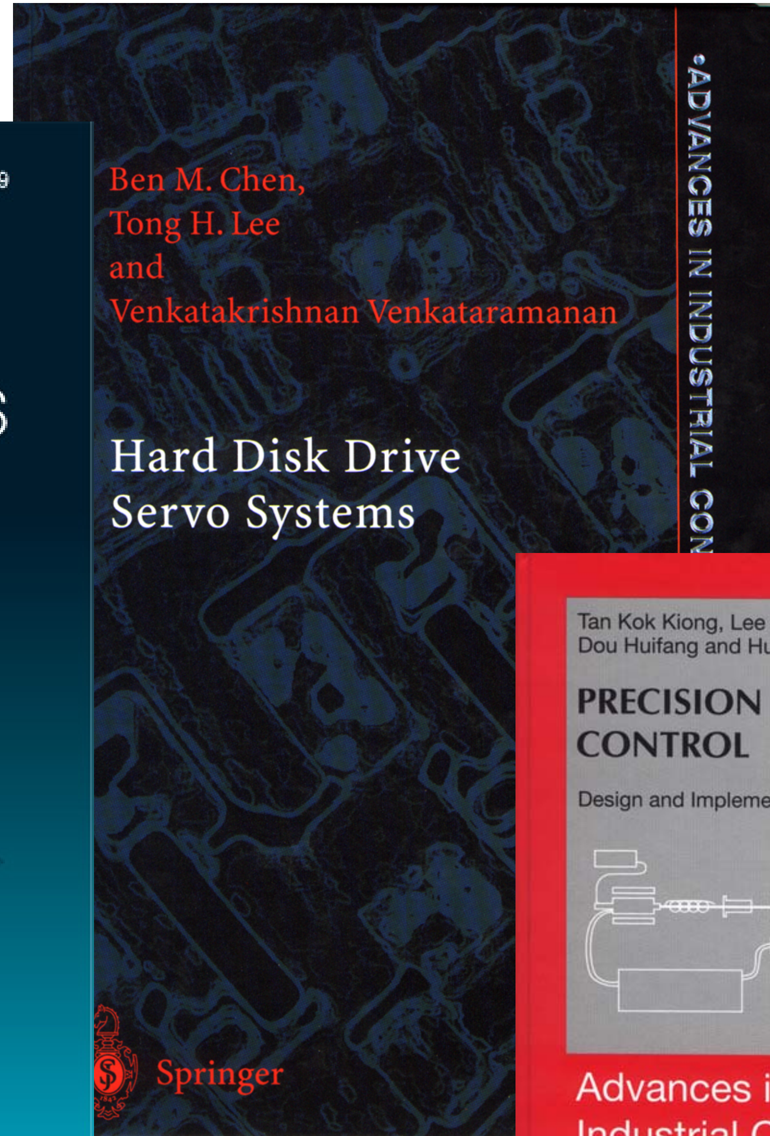
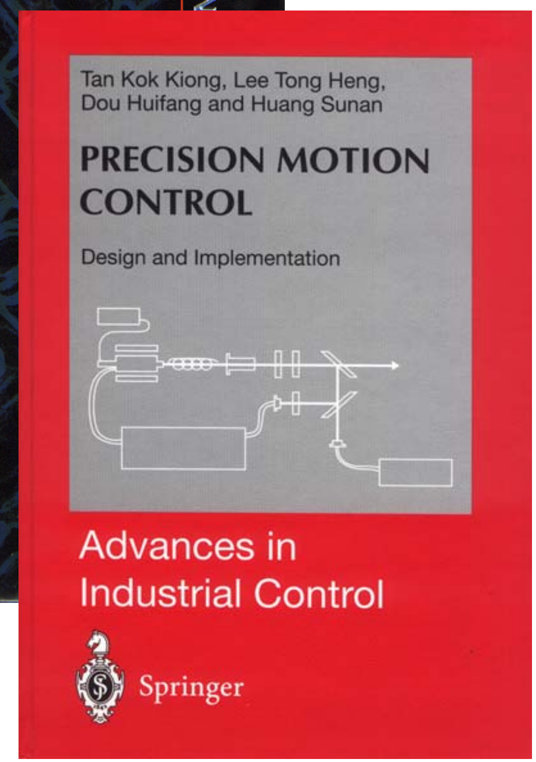
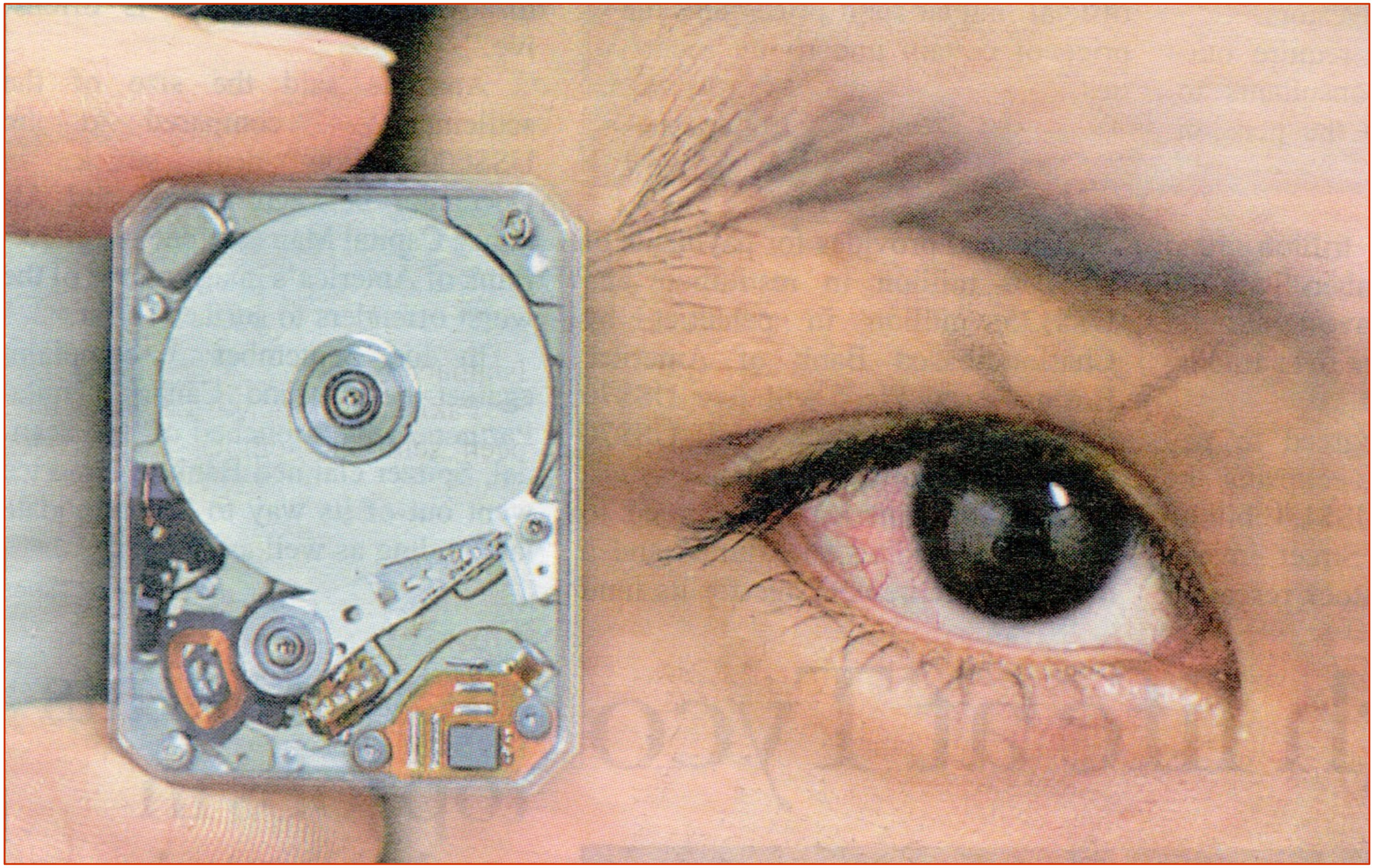
LEE
HARRIS
ADAPTIVE NEURAL NETWORK CONTROL OF ROBOTIC MANIPULATORS


Ben M. Chen,
Tong H. Lee
and
Venkatakrishnan Venkataramanan
Hard Disk Drive
Servo Systems
Springer
ADVANCES IN INDUSTRIAL CON

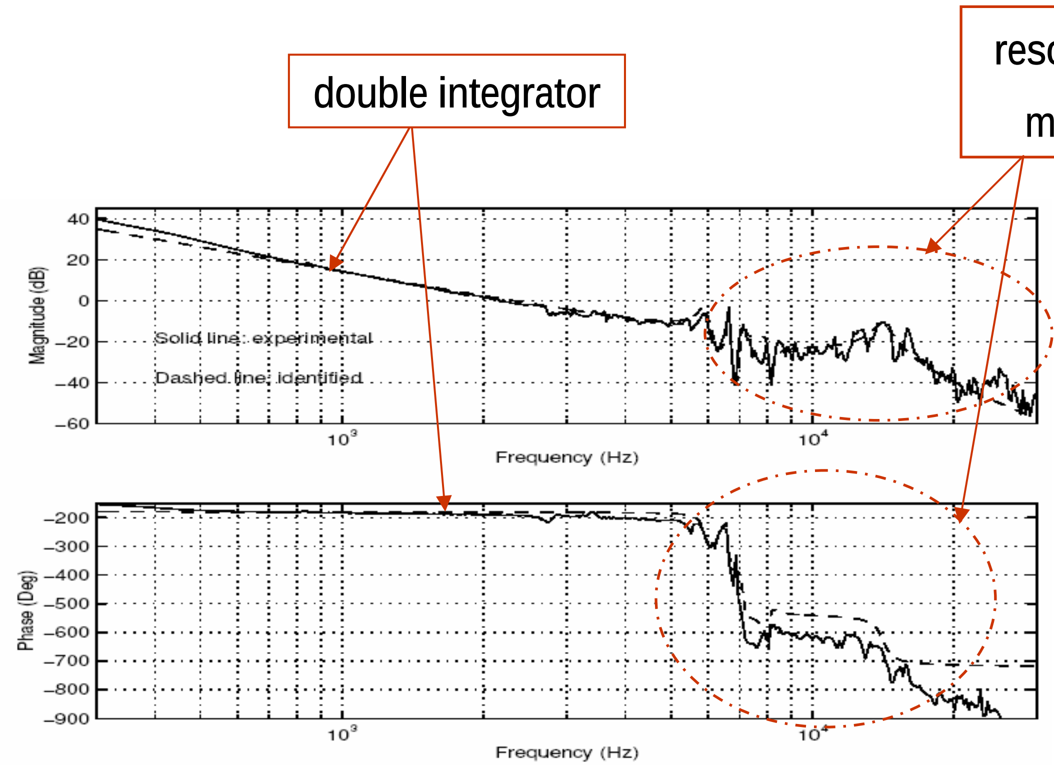

Tan Kok Kiong, Lee Tong Heng,
Dou Huifang and Huang Sunan
PRECISION MOTION CONTROL
Design and Implementation
Advances in
Industrial Control
Springer

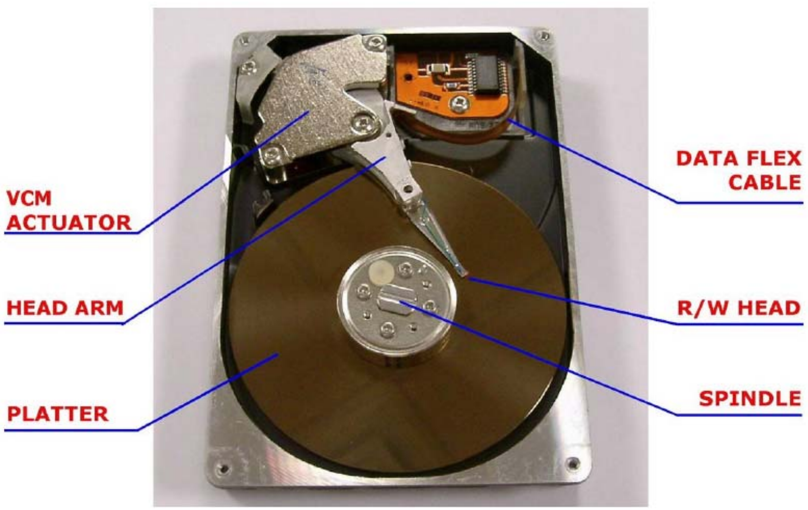
Microdrives (Toshiba 0.85-inch HDD, 4 GB)



Modeling and Identification

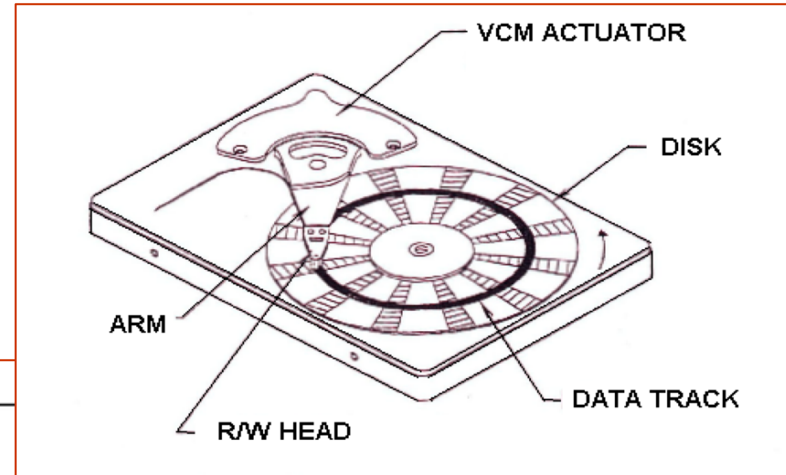
Basically, the HDD VCM actuator displays both linear and nonlinear features in its dynamic model. At the low-frequency range, it behaves as a double integrator (linear), a typical behaviour of servomechanism, and at the high frequencies, it has many resonance modes. Nonlinearities associated with the system are friction and those from data flex cable…

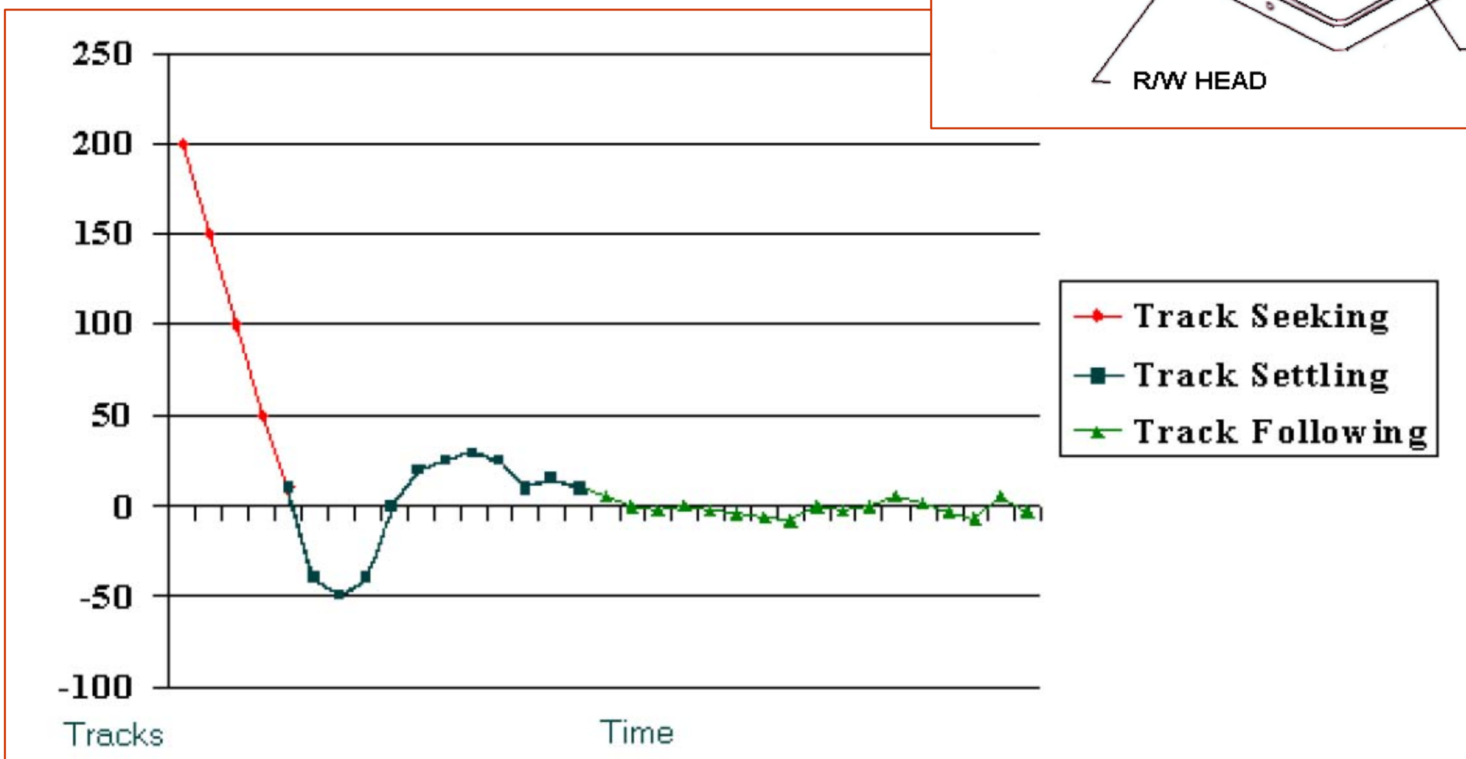




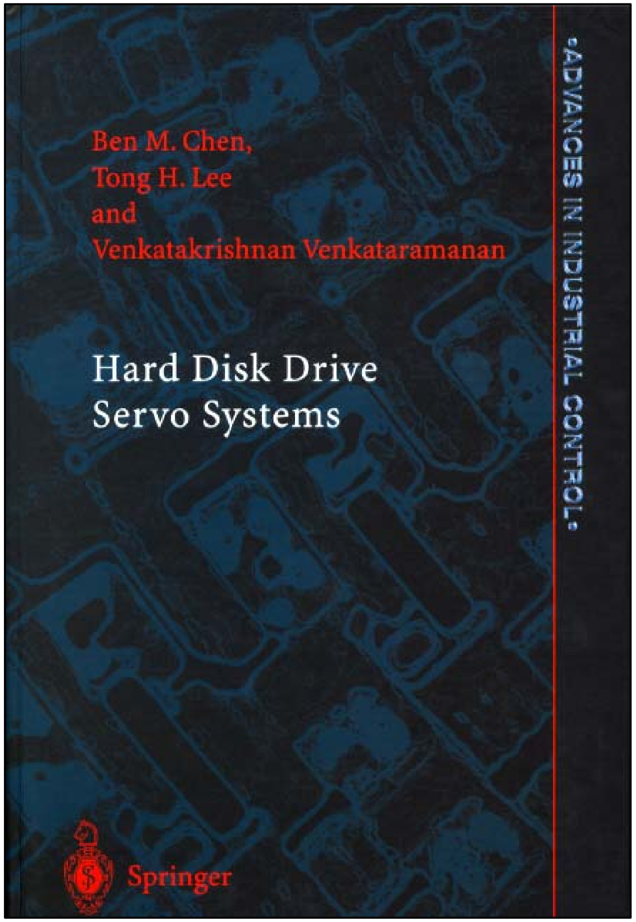
HDD Control Systems

An HDD control system involves two main tasks: track following (**linear control**) and track seeking (**nonlinear control**)…





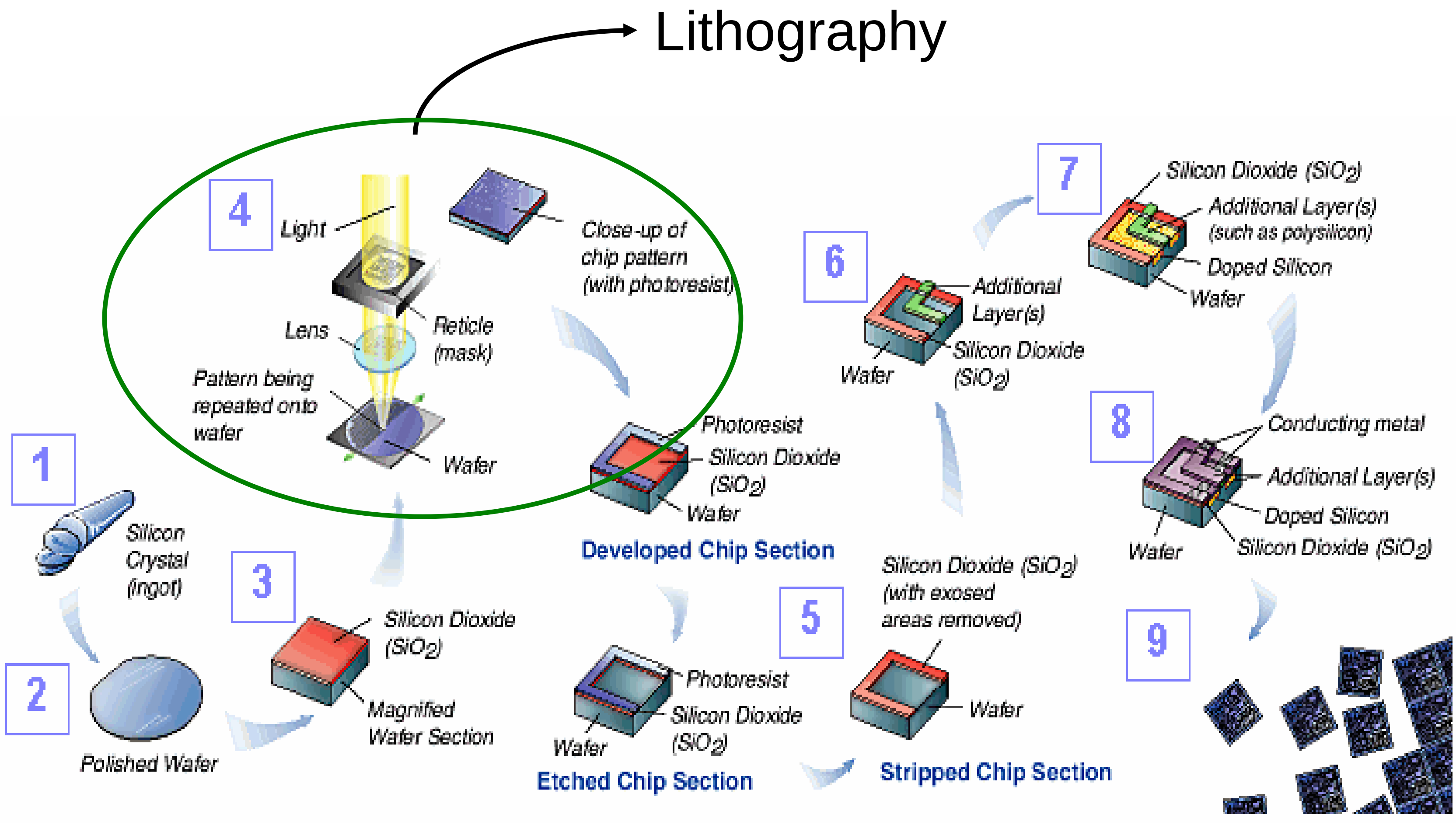
Details described in:



2002

2006

Semiconductor Manufacturing Process



Source: Sematech, Inc.

International Technology Roadmap for Semiconductors: 2002 Update

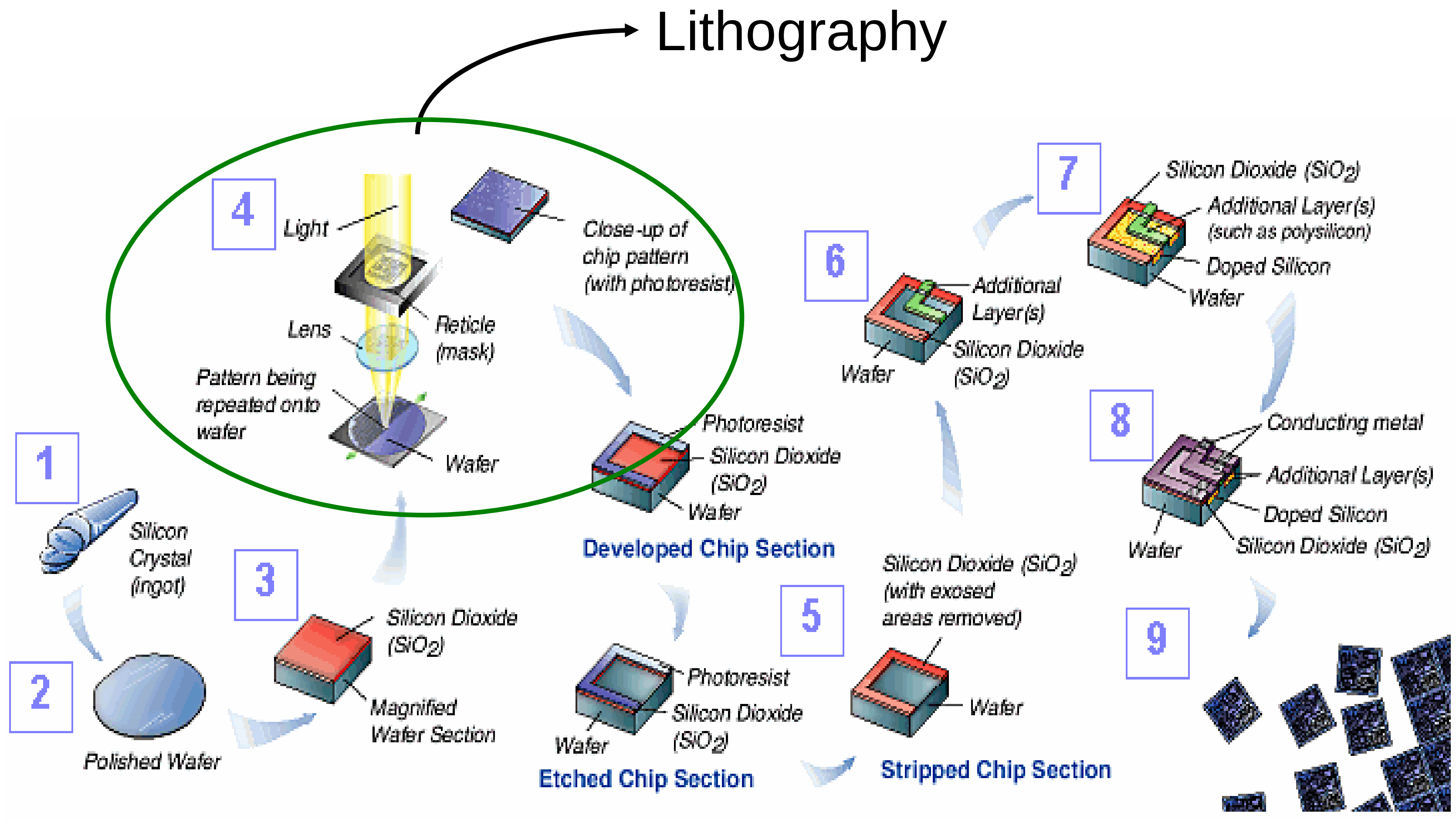
Grand Challenge:

Process control, particularly for overlay and linewidths, also represents a major challenge. It is unclear whether metrology, which is fundamental for process control, will be upgraded adequately to meet future requirements.

International Panel on Future Directions in Control, Dynamics and Systems, AFOSR, 2002:

…use of control is critical to future progress in the semiconductor sector. Modeling plays a crucial role and control techniques must make use of more in-situ measurements to control at a variety of temporal and spatial scales.

Semiconductor Manufacturing Process

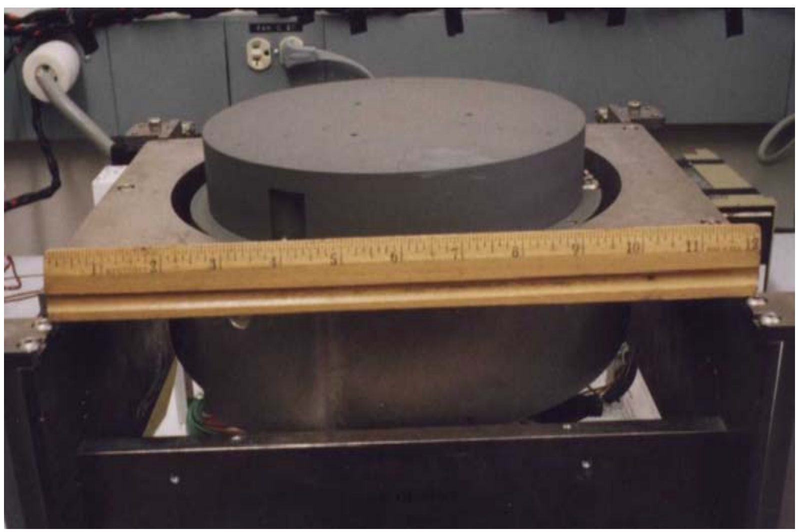


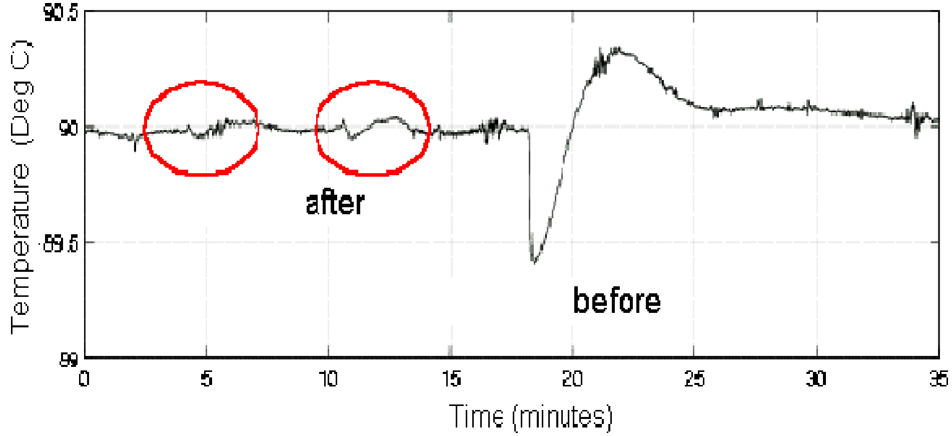
Source: Sematech, Inc.

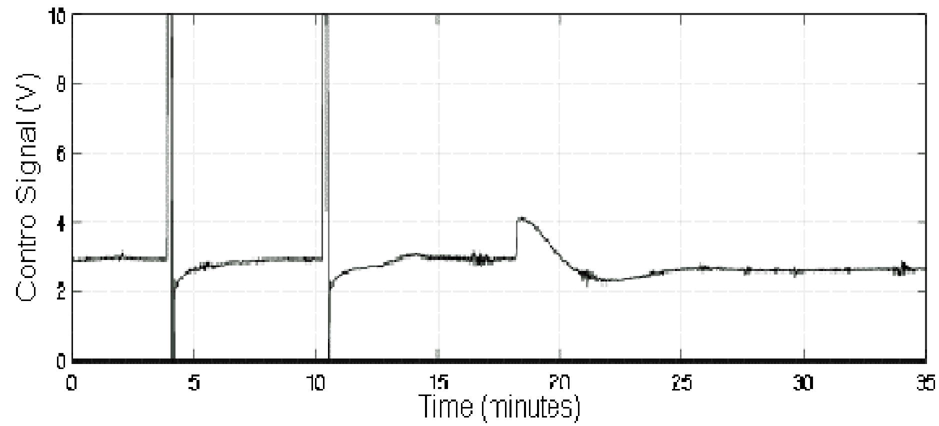
Scope

- Issues in Lithography:
  - Temperature Control
  - Photoresist Thickness
  - Wafer Warpage

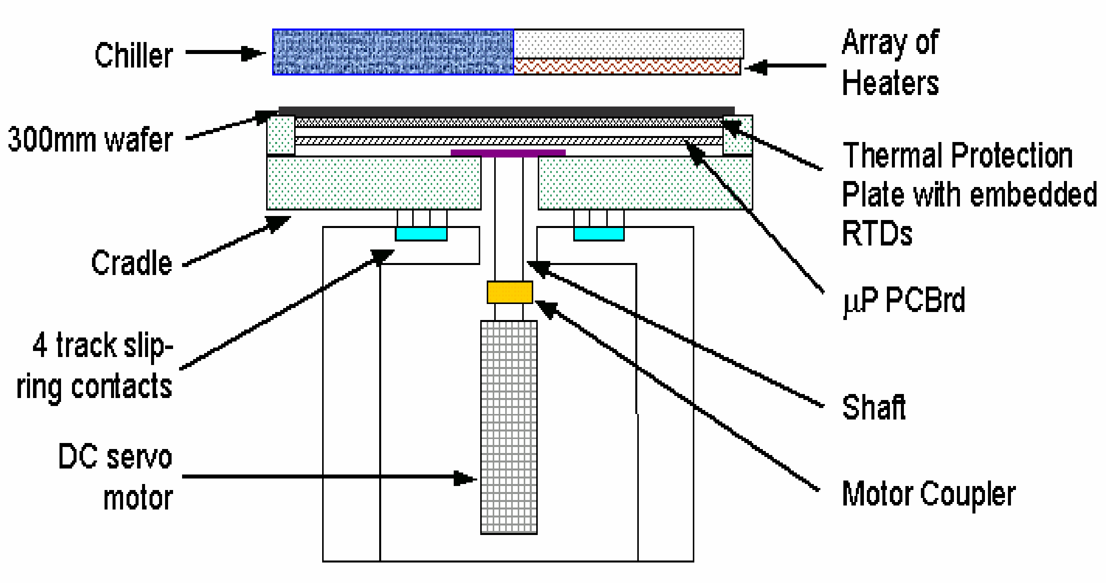
Temperature Control

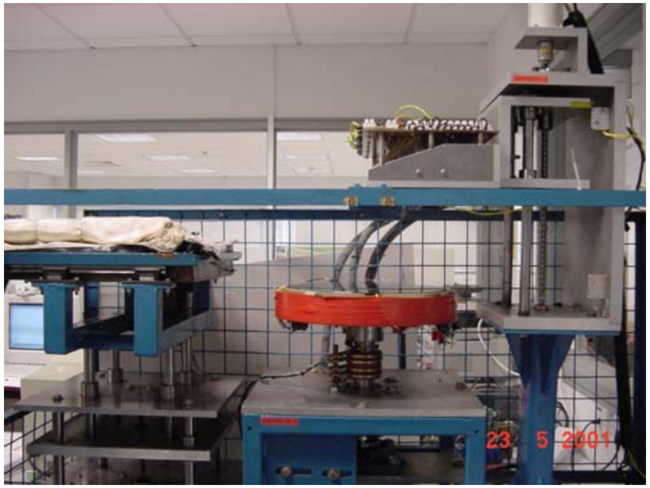


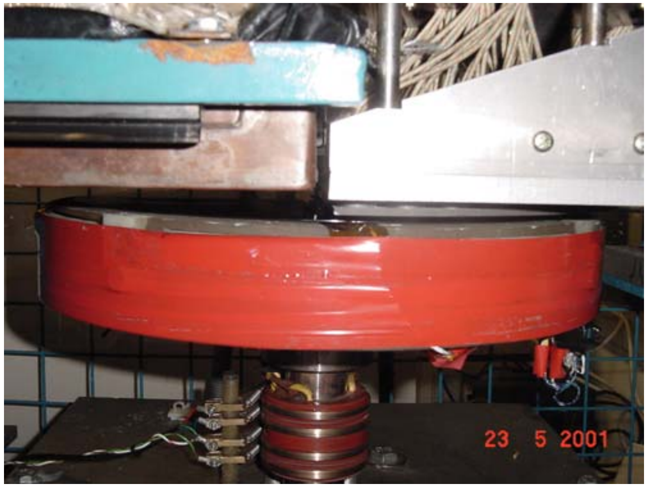




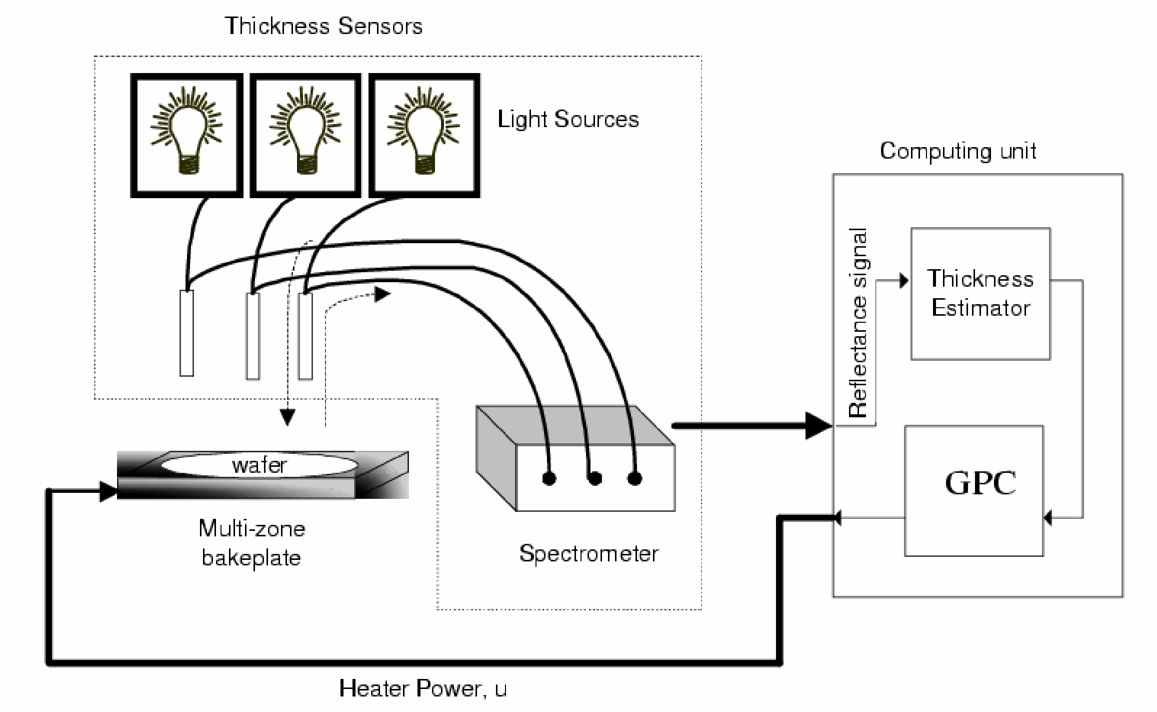
New Thermal System Design



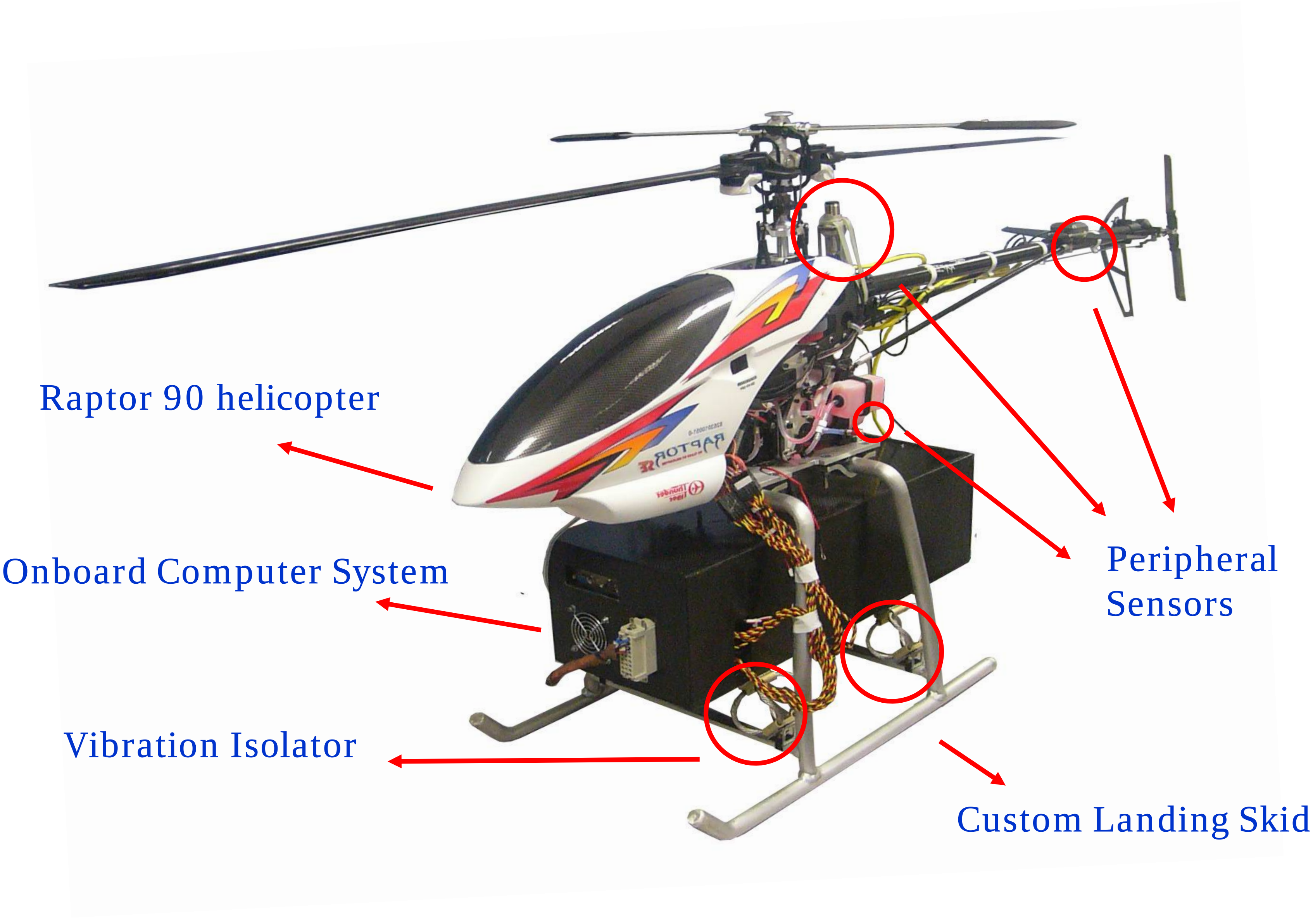




In-situ thickness measurement



UAV (Helicopter) control system



UAV System

Onboard

- inertial measurement
- servo driving
- automatic control
- communication
- data logging

Helicopter

Ground Station

Ground Station

- data transferring (background)
- user interface (foreground)

Linear State-Variable Model

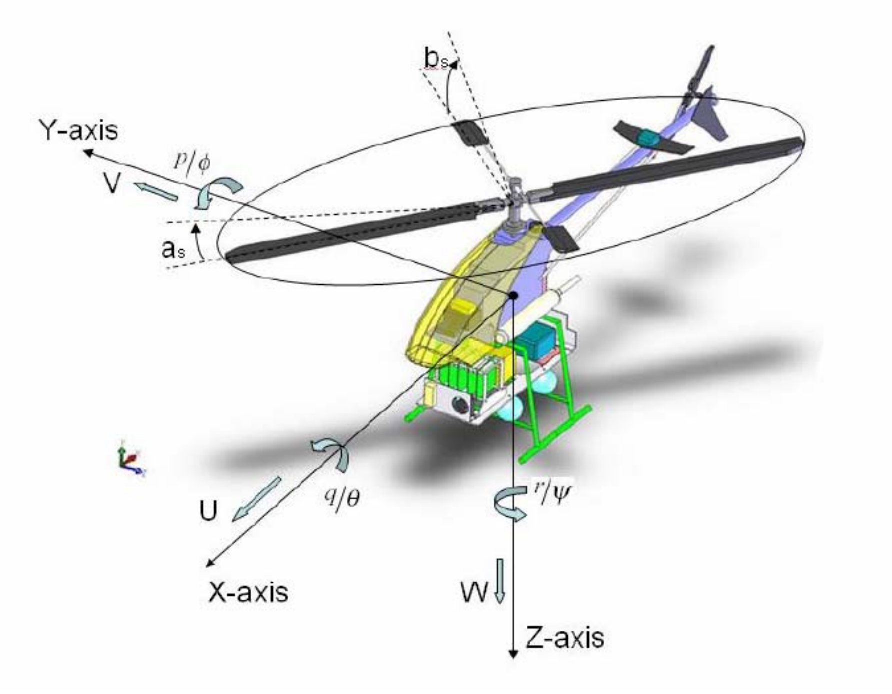
- Linear model for helicopter under specific flight condition

$$\dot{\mathbf{x}} = A\mathbf{x} + B\mathbf{u}$$

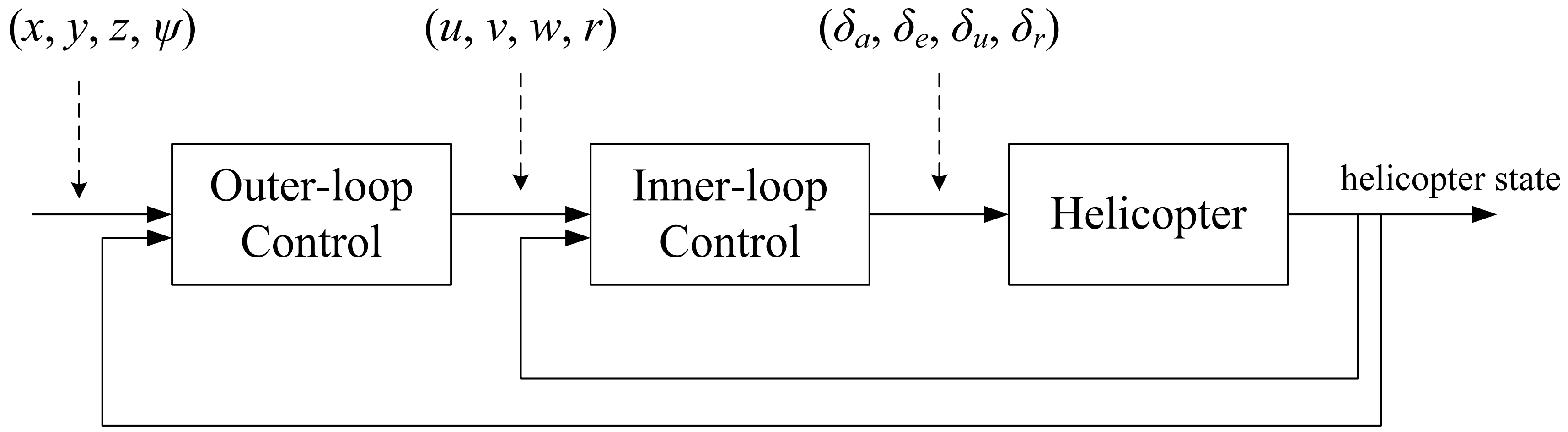
where

$$\mathbf{x} = (u, v, p, q, \phi, \theta, a_s, b_s, w, r, r_f, \zeta_a, \zeta_e, \zeta_u)$$

$$\mathbf{u} = (\delta_a, \delta_e, \delta_u, \delta_r)$$



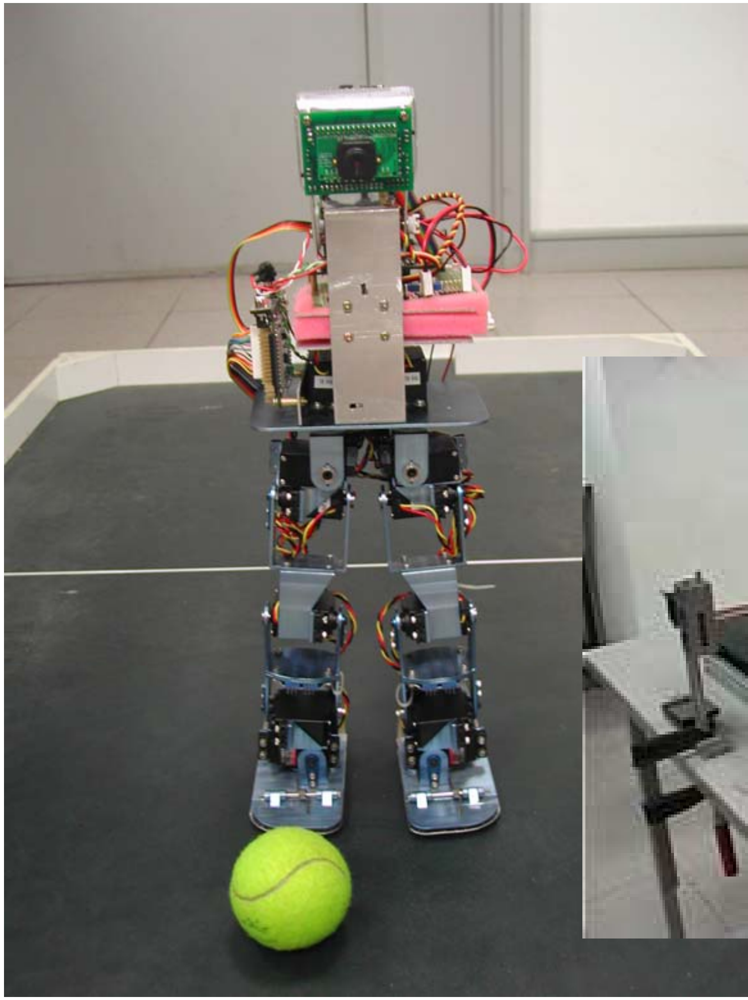
UAV (Helicopter) Control



x, y, z	–	position of the helicopter respective to ground frame (North-East-Down frame)
u, v, w	–	velocity of helicopter along axis in body frame
ϕ, θ, ψ	–	roll, pitch and heading angle of helicopter (NED frame)
p, q, r	–	roll, pitch and yaw rate of helicopter along axis in body frame
$\delta_a, \delta_e, \delta_u, \delta_r$	–	control signal for aileron, elevator, collective pitch and rudder

helicopter state – $(x, y, z, u, v, w, \phi, \theta, \psi, p, q, r)$

MORE SYSTEMS (at CIC, NUS)

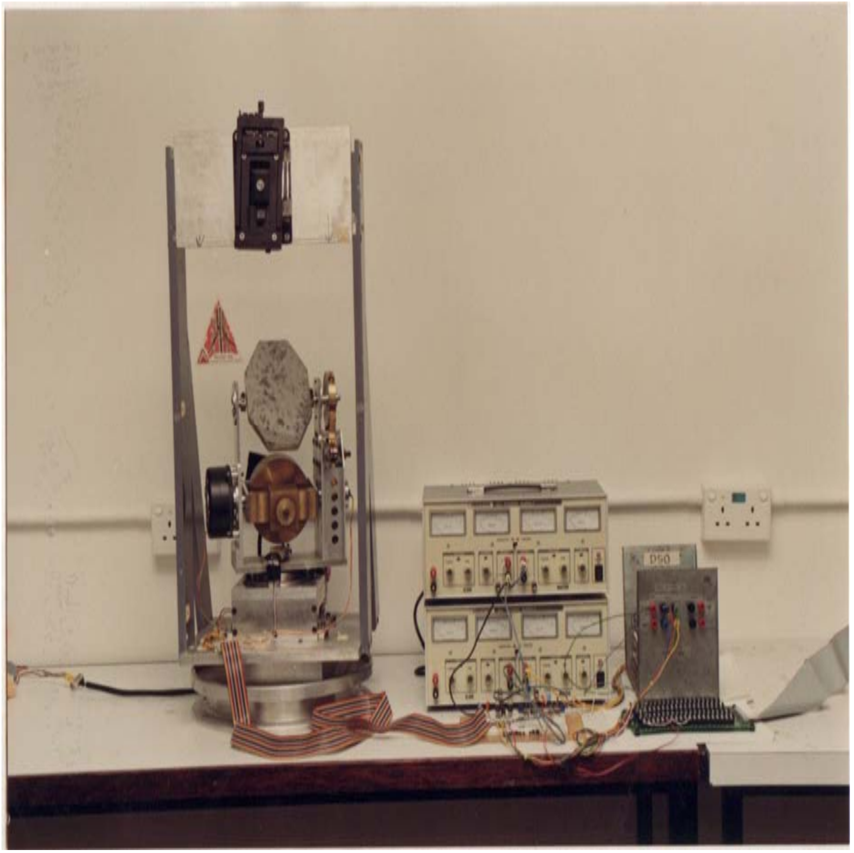


Ge & students

KKTan & students

Prahlad & students (won 1st Prize at FIRA Competition, Austria; 7 Oct 2003)

MORE SYSTEMS (at CIC, NUS)



Gyro-stabilized line-of-sight pointing system